Finding the sweet spot in resource workload

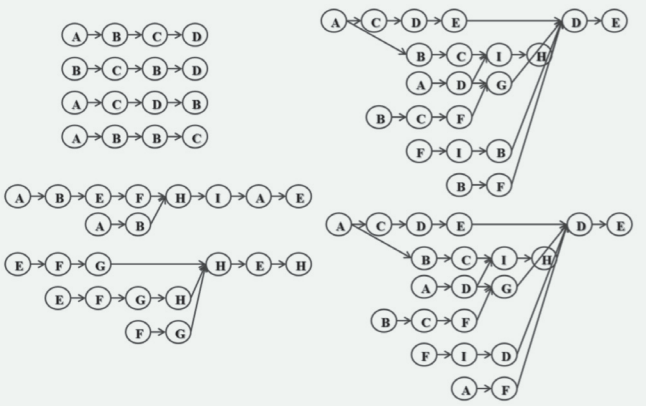
Algorithm combines efficiency and effectiveness for project management

By James R. Holt and Robin Clark

FIGURE 1

So who does what?

Eight projects share nine resources (A, B, C, D, E, F, G, H, I).



Resource overload is a primary cause of bad multitasking and delay in projects. It is very difficult to determine the workload expected to be done by any particular resource at any moment in time. But a simple algorithm can provide a "good enough" indicator to give management the information needed to start or delay additional projects.

To be a good project management organization, the organization must make efficient use of its limited resources. Managers must keep their key resources busy. But an effective project management organization must deliver quality projects quickly and predictably. And this can't happen when key resources are overloaded or distracted. Management too often errs on the side of overloading resources with the hope that individuals will somehow "find a way." The results are delayed projects with less than high-quality content.

In a busy project organization, it is impossible to predict the starting and ending times of individual tasks. However, it is possible to know the amount of planned, uncompleted work flowing toward key resources. By controlling the amount of work a resource must perform over a period of time, management can create a consistent, stable workload that gives faster and more predictable results.

This article introduces a Workload Index to indicate how much work each skill type is required to do during a fixed period in the near future:

Workload Index = (Sum of expected task durations for all uncompleted tasks requiring a specific skill)/(Number of workers with that skill)/(Average length of projects)

Queuing theory in projects

Before discussing the application of the Workload Index, consider how overloaded resources affect projects. Many cities have implemented freeway on-ramp control systems to prevent the roads from becoming too congested during rush hour traffic. By limiting the number of cars on the freeway, the freeways move more cars per hour. This same concept applies to projects.

Queuing theory says the "time to wait for service" is proportional to the "percent of time the server is busy" divided by the "time the server is not busy." This means if a server is busy half the time, the delay factor is 50 percent divided by 50 percent, or one. Increasing the arrival rate to the queue so the server is busy 66 percent of the time gives a delay factor of two (66 percent/33 percent). Increasing the arrival to 75 percent gives a delay of three. Going up to 80 percent, the delay factor is four. Going to 90 percent creates a delay of nine (three times longer than the delay at 75 percent).

In projects, tasks move from resource to resource. Each move puts the tasks into a new queue for the next resource. Project resources that are loaded to 90 percent make tasks wait at least three times longer than the resources loaded to only 75 percent. This very significant delay happens when just a little too much work is assigned. By choking back the release of work just a bit, projects can be completed much faster. And the customer receives the value the project provides much sooner.

Some projects are long and some are short. The Workload Index examines all the active projects of an organization and calculates a simple average of the longest planned length of the projects. This simple average is the sum total of the planned length of each project divided by the number of projects. (This "look ahead period" may change when a new project is started or an active project ends.)

The algorithm adds together the expected task durations of all uncompleted tasks to be done by a specific skill within the "look ahead period." It includes tasks wherever they are within the project execution (this includes tasks yet to be done that are not yet ready for work by the resource). Tasks that are partially completed are considered uncompleted.

There is no need to know the exact work schedule nor the sequence of work. Rather, the Workload Index gives a general indication of the backload of uncompleted work.

Managing and testing the Workload Index

With the Workload Index, management can quickly identify which resources are the most heavily used. These key resources determine the rate at which projects can be completed. If the Workload Index is too high, the project organization overloaded the resources, and project progress will be slow. If the index is too low, expensive resources are starved and the organization is not being efficient nor effective.

To test the resource loading algorithm, eight different projects were simulated using various Workload Index limits. Some were simple, short projects and some longer, more complex projects. There are nine different resources skills (A, B,

C, D, E, F, G, H, I) used in the eight projects, as shown in Figure 1. There is only one worker for each skill. On average, some workers will have more tasks to do than others. The average length of projects was six tasks.

The projects were released at random each day until a specific maximum workload index limit was reached (for any resource in the simulation).

The test Workload Index limits ranged between 17 percent and 400 percent. A Workload Index of 17 percent means that no additional projects will start until every task has less than one task in the system (which means totally completing every task in the project before releasing another project). At 400 percent, no additional project will start until the most heavily loaded resource has less than 24 uncompleted tasks in the simulation. Each simulation was run for 100,000 days.

The completion of individual tasks was simulated by the roll of a fair die. If the die rolled a six, the task was completed that day. If the die rolled any number from one through five, the task was not completed. This daily evaluation method mimics a mean task completion following a beta distribution of $\alpha=2$, $\beta=10$ with range of 0 to 50.

The top line in Figure 2 shows the average number of projects completed during the simulation for each Workload Index value (from 17 percent to 400 percent). The number of projects completed increases from 3,875 at 17 percent Workload Index to 10,070 at 400 percent.

At a Workload Index of 400 percent, the most heavily loaded resource was busy 99 percent of the time. Increasing the Workload Index above 400 percent did not increase the number of projects completed.

FIGURE 2

Projects completed and completion time

Projects completed for each different Workload Index. Average completion time is at a 90 percent confidence level.

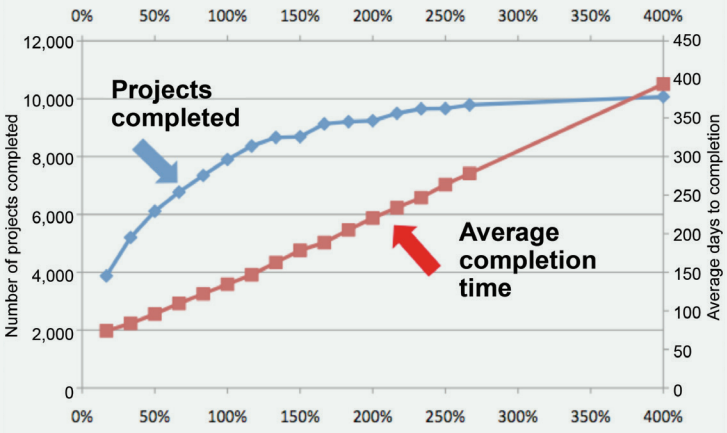
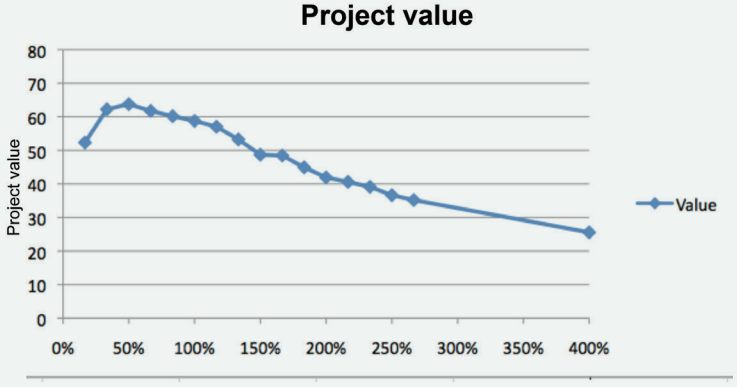


FIGURE 3

Value of projects by Workload Index

Value is the number of projects completed divided by the average completion time.



The lower diagonal line in Figure 2 shows the average expected time to complete a project (at a 90 percent confidence interval). The time to complete a project at a Workload Index of 400 percent is 394 days, more than five times longer than the 74 days at 17 percent. (Increasing the Workload Index levels above 400 percent puts longer queues at the most heavily used resources and more work on the less busy resources. Both increases delay work as well. Releasing work above 400 percent continued to increase the average project completion time in a linear fashion.)

To find the best middle ground between the higher number of projects completed versus having shorter project durations, a measure of Value was calculated. The arbitrary Value used in this simulation was Value equals the number of projects completed divided by the average time to complete a project. Figure 3 shows that the Value measure peaked when the Workload Index was well below 200 percent.

The data generating the Value measures in Figure 3 also shows that the most heavily used resource was busy 75 percent of the time (awaiting work 25 percent of the time) at the Workload Index of 83 percent (there were no additional projects started until the number of uncompleted tasks for the most heavily loaded resource was below five tasks). With a Workload Index of 167 percent (no new projects released until the number of uncompleted tasks was below 10 tasks), the most heavily used resource was busy 90 percent of the time (awaiting work 10 percent of the time).

FIGURE 4

Adding a priority system

Telling each worker what task is the most important increases the overall project value.

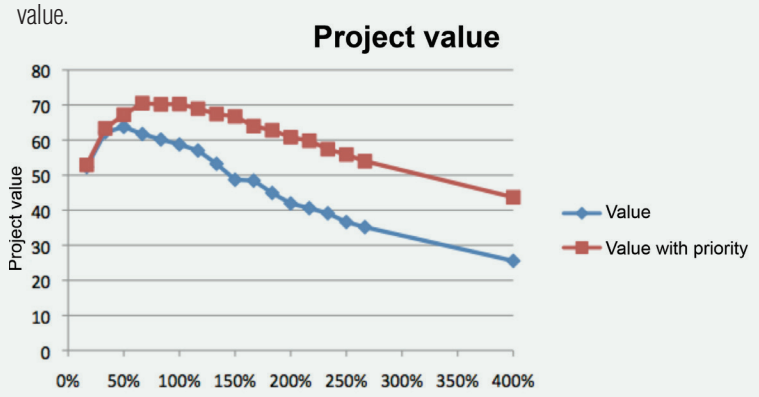
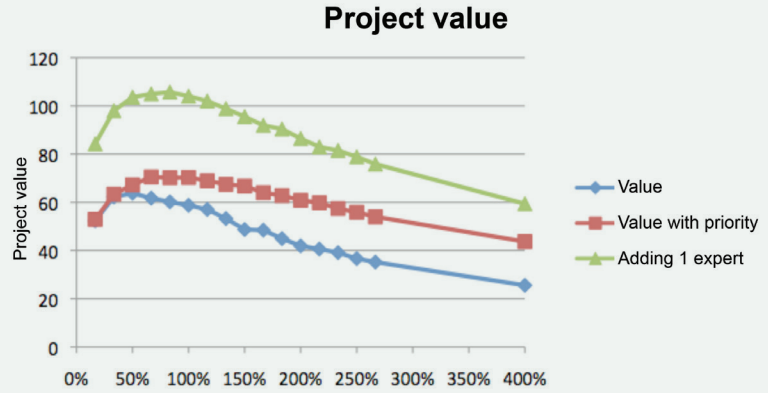


FIGURE 5

Adding an available expert resource

Adding an expert to help workers who are taking longer than the task's expected completion time adds significantly to project value.



Adding priorities, handling difficult tasks

In the simulations reported so far, the workers performed the tasks in a multitasking way. If a worker had several tasks in a queue, each day the worker would select the first task in the queue and work on it (roll the dice). The task was completed one-sixth of the time. If the task was not finished that day, that task went to the back of the queue. The next day, the worker would select the first task at the front of the queue. This type of multitasking continued throughout the simulation.

What if each worker was told every day which task in their queue was the most important task for the whole organization? If the worker could focus on the most important task continually until it was complete (work on the same task day after day until it was completed) before working on other tasks in the queue, things should improve. Right?

The priority system used in this test gave first priority to the tasks of projects with the earliest start date. (This arbitrary priority system shows what would happen with almost any priority system.)

The results were amazing. The reduction in multitasking and the movement of older projects to the front of the queue dramatically increased the value of the project system, as shown in Figure 4.

In projects, there are lots of unknowns. That is why the beta distribution is used in estimating task durations. This simulation used rolling a fair die to get a six (a one-sixth chance of completion each day). While the average time to roll a six logically seems to be six rolls, the beta distribution shows it can frequently take more than 12 rolls to get a six, and too often more than 20 rolls (try this yourself).

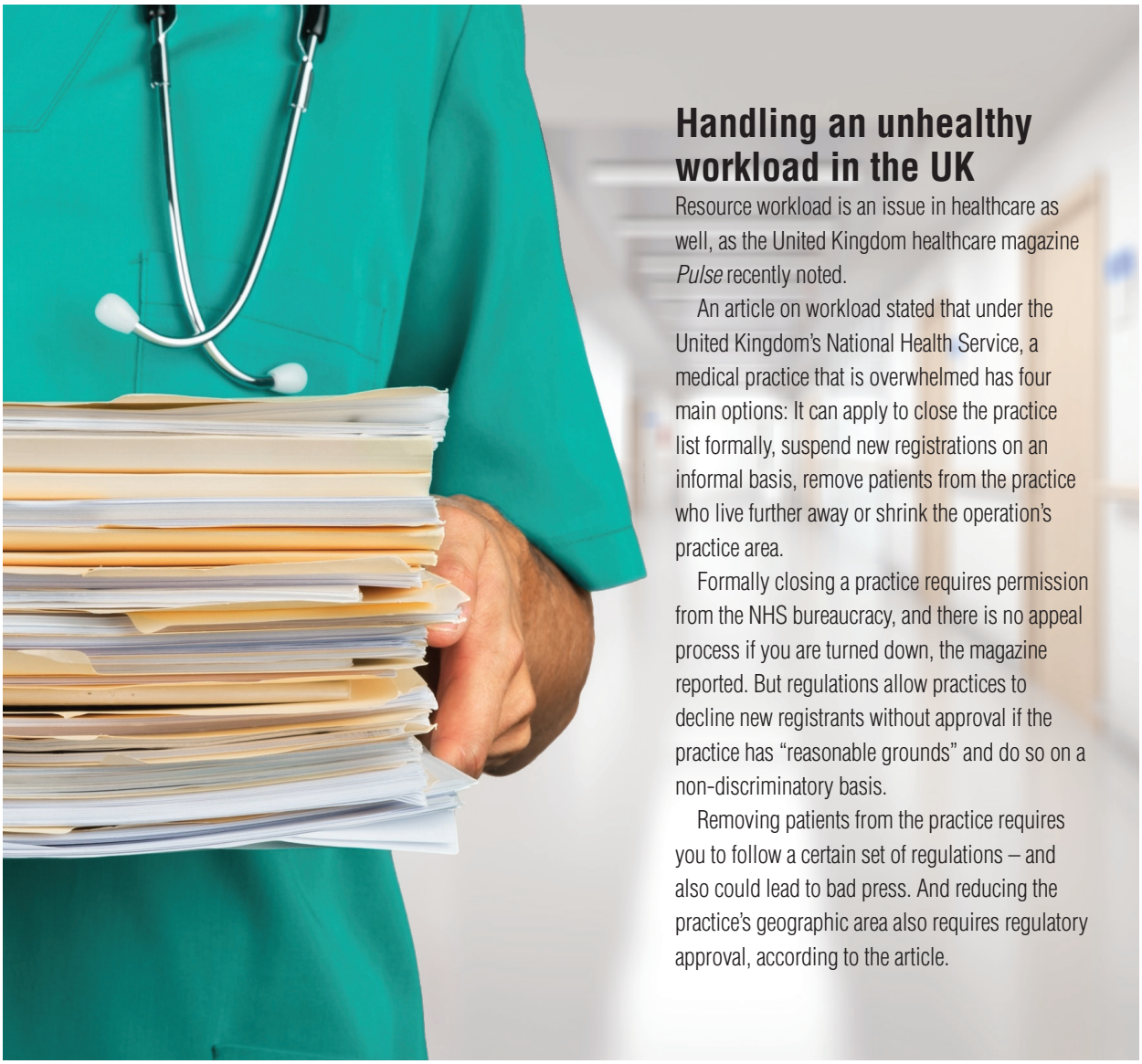
Any task in the project could have bad luck and take much, much more time than expected. And almost any task that takes significantly too long will delay the project. If there were a way to cut off the long tail of the beta distribution, things would be much better.

The final test simulations considered the possibility of having an additional "expert resource" available to assist any worker who had not completed his or her task within six rolls. The expert would be someone who is qualified to assist any skill. The expert adds a 10th person to the resource pool. However, no specific assignment is given to the expert. Whenever a worker was having trouble with a task (has not completed the task after six rolls), the expert would "join" the troubled worker. The worker and the expert would both work on the priority task. They would both roll their dice each day until one of them gets a six (effectively doubling the probability of completion to one-third).

At a Workload Index of 17 percent (doing only one project at a time), the expert was busy working with someone about 50 percent of the time (that is, the expert was busy helping one of the other nine resources half the time). At a Workload Index of 200 percent, the expert was busy 85 percent of the time. (The expert could only help one person at a time.) Having this expert available significantly reduced the average expected completion time and increased project value. The impact of adding an available expert resource is shown in Figure 5.

Bottom line

Choking the release of new work and reducing the Workload



Handling an unhealthy workload in the UK

Resource workload is an issue in healthcare as well, as the United Kingdom healthcare magazine *Pulse* recently noted.

An article on workload stated that under the United Kingdom's National Health Service, a medical practice that is overwhelmed has four main options: It can apply to close the practice list formally, suspend new registrations on an informal basis, remove patients from the practice who live further away or shrink the operation's practice area.

Formally closing a practice requires permission from the NHS bureaucracy, and there is no appeal process if you are turned down, the magazine reported. But regulations allow practices to decline new registrants without approval if the practice has "reasonable grounds" and do so on a non-discriminatory basis.

Removing patients from the practice requires you to follow a certain set of regulations – and also could lead to bad press. And reducing the practice's geographic area also requires regulatory approval, according to the article.

Index from 400 percent to 200 percent increased the value of project organization 65 percent. Adding a priority system that identified the most important task for each worker increased value another 45 percent at a Workload Index of 200 percent. Adding one expert increased project value an additional 40 percent at a Workload Index of 200 percent.

The first two actions (choking the amount of work, establishing task priorities) can be easily implemented, either independently or together. It's a little harder to find where the expert is needed.

Either way, the Workload Index is reasonably easy to calculate. It is a good tool for monitoring active workload. With some additional effort, it is clearly possible to double the value a busy project management organization delivers to its customers.

The Workload Index can also help plan the release of future work. It enables a "What if …?" capability to measure the impact releasing a candidate project will have on the whole organization. Management can compare the impact of different options under consideration and make informed decisions. Tracking the Workload Index over time gives management a valuable tool to manage the workload in their organization. ❖

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